the anatomy of

TIME

THE ANATOMY OF

Time

WITH THE COMPLIMENTS OF

THE ROLEX WATCH COMPANY LIMITED

OF GENEVA SWITZERLAND

SECOND EDITION

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"That great mystery of TIME, *were there no other; the illimitable, silent, never-resting thing called Time, rolling, rushing on, swift, silent, like an all-embracing ocean-tide, on which we and all the Universe swim like exhalations, like apparitions which* are, *and then* are not*: this is forever very literally a miracle; a thing to strike us dumb, — for we have no word to speak about it."*

THOMAS CARLYLE

"What is the time? It is
Midnight. See, here I have set
A little clock, to mark the hour"

THOMAS BEDDOES *Death's Jest Book*

Introduction

SURELY not one of us, even the least imaginative, can consider Time without some feeling of awe.

Your watch, the church clock, the punctual train, the unpunctual poet, are one with the stars and, ultimately, Eternity. The man who wrote:

I saw Eternity the other night,
Like a great ring of pure and endless light,
All calm, as it was bright;
And round beneath it, Time in hours, days, years,
Driv'n by the spheres
In a vast shadow mov'd; in which the world
*And all her train were hurl'd.**

anticipated by some centuries the sober thoughts of present-day physicists. For Time is part of eternity, bound up with the great mysteries of the metaphysician and the philosopher, Space, Matter, Motion, Force, and Consciousness.

Time is not the hand of a clock moving round, not the Time the man-in-the-street thinks he knows it to be. It is something far greater; a fourth dimension, an integral part of the Universe.

As we go out in space we go back in Time, the physicists tell us; and Einstein sums up in a single equation a view of a co-existent Time-Space which few of us understand. Minkowski said, of the Theory of Relativity, "From henceforth, space in itself, and time in itself, sink to mere shadows, and only a kind of union of the two preserves an independent existence." Somewhere there in that statement is the elusive truth about Time.

Wells tried hard to make us see it. The Time Traveller insisted on the necessity of regarding Time as a fourth dimension, as a way

* Henry Vaughan, 1622–1695. *Silex Scintillans. The World.*

in which matter *must* be measured. " 'Clearly,' the Time Traveller proceeded, 'any real body must have extension in *four* directions: it must have Length, Breadth, Thickness, and – Duration. . . . There are really four dimensions, three of which we call the three planes of Space, and a fourth, Time. There is, however, a tendency to draw an unreal distinction between the former three dimensions and the latter, because it happens that our consciousness moves intermittently in one direction along the latter from the beginning to the end of our lives. . . . *There is no difference between Time and any of the three dimensions of Space except that our consciousness moves along it. . . .*' " *

But however much the scientists strive, Time to most of us is the ticking of the clock; something that is continually passing, never to return, something along which we move; ideas which are anathema to the scientist but merely logic to the layman.

Let Dunne have the last word. "The Time dimension was represented (to the man-in-the-street) by the circumference of a circle, this length being marked off into portions representing Time distances. But that alone did not suffice to convey his conception of Time. There was no moving 'present.' So he added a pointer to represent this 'present,' and set it moving over the symbolic Time dimension by means of machinery. The entire contraption was then not only a symbol, but an actual working model of Time as he conceived it. It was an extremely useful device; and he called it a 'clock'." †

This is the story of the "extremely useful device" that to most of us means Time.

* H. G. Wells. *The Time Machine* (1895).

† J. W. Dunne. *An Experiment with Time* (1927).

First Watch

i. SUN ii. WATER iii. SAND – AND FIRE

First Watch

i. SUN

AS FAR AS WE KNOW, man first began to measure time by a device between the 10th and 8th Century before the birth of Christ. Measure time, that is, into more divisions than three, for even to prehistoric man, the twenty-four hours split themselves into three natural divisions; from dawn to noon (the highest point of the sun), from noon to dusk, and the hours of darkness.

And so our clock watcher of those days used the sun as his time measurement; he made, in fact, a sundial. This dial, the earliest of which we have any certain knowledge, is Egyptian, now in the Berlin museum, and dates from approximately the 9th Century B.C.

But as quite often happens, history is uncertain who *first* noticed that the shadows cast by the sun moved and were regular, and conceived the idea of using them to tell the time. On the basis of this Berlin dial, modern historians are inclined to credit the Egyptians. The Israelites knew all about sundials. "Behold, I will bring again the shadow of the degrees, which is gone down in the sun dial of Ahaz, ten degrees backward. So the sun returned ten degrees, by which degrees it was gone down," * says the Bible, fixing the date of this Israelite sundial nearly 200 years after the Berlin dial, for King Ahaz did not reign until the 7th Century B.C.

It is possible, too, that the Babylonians, that cultured and inventive race, learnt the art of telling time from the Egyptians; Herodotus † claims they invented it, but it is more likely that they merely took the principle and improved it.

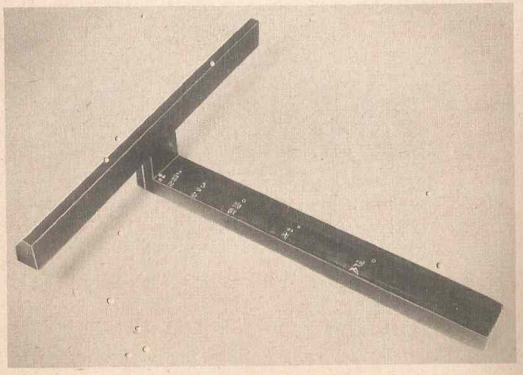
* Isaiah 38. 8. Some authorities hold that a more correct translation would have been "down the *steps* of Ahaz, ten *steps* backwards." But even this argues that the principle was known.

† Herodotus Lib. II.

After the Babylonians, the Greeks; the Tweedledum and Tweedledee of Greek philosophy, Anaximenes and Anaximander, have both been credited with the discovery of the sundial, Anaximenes by Pliny, and Anaximander by Phavorinus.

These two philosophers were both of Miletus, lived and were associates in the latter half of the sixth century before Christ. Anaximander was the gentleman who held that the first generation of men was born from huge fishes "for had he been originally as he is now, he would never have survived," an idea not really so very far removed from Darwin; while Anaximenes' speciality was air, which, he said, expands with heat and contracts with cold, and by these changes is the source of all existing things.

Present-day philosophers agree that many of the philosophical speculations of both men were sound, and it is certain that either of them was quite capable of conceiving a time-measuring instru-



The earliest sundial known with certainty. An Egyptian dial of c.900 B.C., now in a Berlin Museum. (Crown copyright. Reproduced by courtesy of the Science Museum.)

ment. But what is most probable is that one of them introduced the principle to Greece, having learnt it from one of the near Eastern nations.

During the three-hundred-odd years between the Berlin dial and the hey-day of Anaximander and Anaximenes, the dial had evolved greatly, and has been found in many different forms. There was the T-shaped Berlin dial, and a simplification of it, which could merely be an upright, shadow-casting perpendicular* surrounded by a ring of equidistant stones. Sometimes these uprights, obelisks most of them, carved with strange gods and stranger hieroglyphics, still survive, and now we are able to translate the Egyptian picture-writing, we know that they were used for a variety of things; for estimating, for instance, the time taken to complete a task, and the amount of money earned thereby, for religious ceremonies, and for sentries' hours of duty.

Another form of dial was the *polos*, which consisted of a basin marked with twelve lines radiating from a centre, at which was erected the gnomon; and the Greeks, with their great progress in geometry and kindred arts, were able to develop more and more complex dials, called Sciathericum, from skia, a shadow.

The Romans, successors to the imperial crown of Greece, were primarily a race of warriors, statesmen, and poets: their true scientists were few and consequently the art of time-measurement was slow in flowering among them.

The first dial in Rome was not erected until 290 B.C. when one was set up by Papirius Cursor near the Temple of Quirinus which had been taken from the Samnites, while the first dial actually constructed in Rome, by order of Q. Marcius Philippus, was made as late as 164 B.C.

The Arabs, perhaps the master mathematicians of their day, were

* The shadow-casting upright of all sundials is known to horologists as the *gnomon*.

more inventive. They attached great importance to horology,* and took and greatly improved many of the Grecian principles of shadow clocks.

One of their greatest thinkers, Abu'l Hassan, who lived about the beginning of the 13th Century, conceived at least one all-important step in the history of horology, the system of reckoning by equal hours. There is evidence that the Arabs constructed some of the earliest dials in which the *gnomon* is set parallel to the earth's axis, and with which the same scale of equal hours serves for all seasons of the year.

For many years after Abu'l Hassan, the dial changed little, although more and more elaborate forms made their appearance. Even the introduction and gradual perfection of clocks and pocket watches did not oust the dial from public favour; for watches were expensive, and beyond the reach of the ordinary man.

Dialling gradually became a popular science.

Shakespeare's fool, even, carried and used a dial.

> "*And then he drew a dial from his poke,*
> *And, looking on it with lack-lustre eye,*
> *Says, very wisely, 'It is ten o' clock!'* " †

Among the earliest European writers on *gnomonics*, or dialling, was Sebastian Münster, who published *Horologiographia* in Basle in 1531.

Münster was born at Ingelheim, in the Palatinate, in 1489. He became a friar, entering the Franciscan order, but in about 1529 he was won over to Lutheranism, and, later, appointed Court Preacher at Heidelberg. He taught at Basle from 1536 and died of the plague on May 23rd, 1552.

Apart from his great work on the art and science of dialling,

* Horology: the art and science of time measurement.

† As You Like It. Act II, Sc. vii.

SEBASTIANVS MVNSTERVS.
Cosmographus noſtri, felix Germania, ſæcli
Munſterus fuerit magnus et eximius.
Sed pietas ingens religuis virtutibus aucta,
Hunc meritò fecit commemorare virum.
Cum priuil.

Sebastian Münster, born in 1489, a friar who was later won over to Lutheranism, was one of the earliest European writers on dialling. (*Reproduced by courtesy of "Picture Post".*)

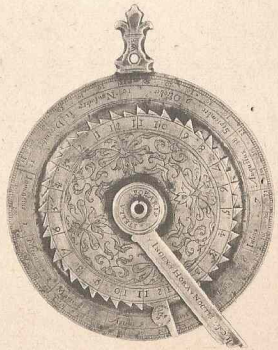
he also produced his *Cosmographia universalis* (*Beschreibung aller Länder*), published in 1544. It was a detailed, scientific, and popular account of the world, according to the ideas of the time, written in German, and in writing it Münster made use of 120 collaborators.

His work on dialling was more than theoretical and written; he pioneered a number of improvements to the dials of that period, and among his inventions was a moon-dial.

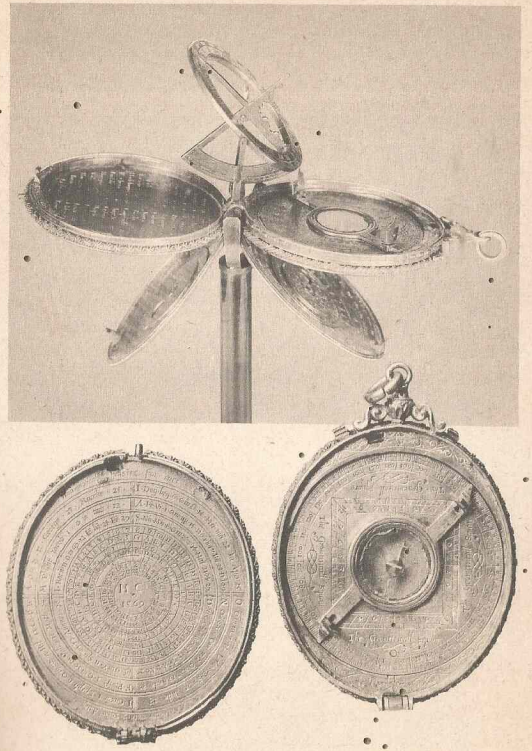
A dial adapted for use as a moon-dial, when the moon's age is known, may still be seen at Queens' College, Cambridge, England.

As an example of the complexity dials of this period could attain, the portable dial of Sir Francis Drake is, perhaps, paramount. It was made by an Englishman, Humphrey Cole, and could be adjusted both for latitude and longitude by means of a quadrant and a magnetic compass; it includes a tide-table, a diagram of planetary aspects, a circumferentor, and a nocturnal.

Nocturnals are rather interesting. They first made their appearance in the reign of Henry VIII, and they serve to tell the time at night, with the observation of fixed stars taking the place of the



A nocturnal, made by Humphrey Cole. Nocturnals first appeared in the reign of Henry VIII, their purpose being to tell the time at night by the observation of fixed stars. (Reproduced by courtesy of the Trustees of the British Museum.)



Drake's Dial, also by Humphrey Cole, includes a tide-table, a diagram of planetary aspects, a circumferentor, and a nocturnal. (Reproduced by courtesy of the Trustees of the National Maritime Museum.)

observation of sun-cast shadows. The principle used is to take the Pole Star as the centre of an immense twenty-four hour clock, with a given star – one of the pointers of the Great Bear was popular – taking the place of the hour hand. As the given star moved round, it indicated the time on the dial through which the operator looked at it.

Drake's dial may be taken as the high spot of dials and of dialling, for during the seventeenth and eighteenth centuries their popularity began to decline. Clocks were becoming more accurate, watches less of a scientist's plaything, more of an ordinary man's possession.

But even today, dials can still be found in use. The old sundial in an English garden may be chiefly ornamental; but it still tells the time, i.e., solar time, and, with the help of an "Equation of time" table, mean time. Dials are still in use in some remote parts of the Pyrenees, linking the twentieth century almost directly with the Egypt of the Pharaohs, fifteen hundred years before the birth of Christ.

ii. WATER

THE USE OF WATER as a means of measuring time is almost as old as the use of a moving sun-cast shadow. In fact, the precise antiquity of the *clepsydra*, or water-clock, is unknown.

One of the earliest forms of which we have any knowledge is a water-clock found in the ruined temple of Karnak in Upper Egypt in 1904. It dates from the time of King Amenhotep III, who reigned from 1415–1380 B.C.

In this early form the clepsydra merely consisted of a vessel from which the water flowed at a uniform rate, the falling level marking the hours on a scale inside the vessel. On the Karnak clepsydra there are twelve series of dots, one series for each month, and above each scale is marked the name of the month to which it belongs.

A more advanced form of this type of clepsydra had a miniature

One of the earliest forms of clepsydra, or Egyptian water-clock, dating from around 1400 B.C. As the water flowed out of the vessel, the falling level marked the hours. (Crown copyright. Reproduced by courtesy of the Science Museum.)

boat floating on the surface of the water, a tiny oar pointing from it to hour marks on the inside of the bowl.

In many of these clepsydra, the hole through which the water leaked was bored through a pearl; for it was supposed that the constant flow of water would wear away all other materials, and that a pearl could not become choked with sediment.

Another common form of clepsydra, working on the opposite principle, was the sinking bowl. It is even harder to determine the age of this device, but it must be of an astonishing antiquity. Invention of it cannot be limited to the Egyptians, for water-clocks of this type have been found in places as far apart as Britain and Ceylon. But the idea is simple, and it could easily occur to people quite independent of one another.

The method was merely to punch a small hole in the bottom of a bowl and place it upon the surface of the water. The interval before it sank was the time interval; and there were bowls constructed for various lengths of time, roughly approximating to one hour, two hours, and so on. Bowls of this sort, interestingly enough, are still used in Algeria for timing the periods in which landowners are entitled to water for irrigation purposes.

In Greece and Rome, clepsydrae were used in the courts of justice to regulate the amount of time accused and plaintiff, or their counsels, could speak, "the first water," says Aeschines, "being given to the accuser, the second to the accused, and the third to the judges." Pliny coins the phrase *aquam dare* – speaking time.*

A special officer was appointed by the court, whose sole duty was to watch the clepsydra, checking the length of the speeches, and stopping the device when any documents were read, or any interruption ensued; taking care, in fact, that the speaker should get his full allowance. The more important the case, the greater the length of speech allowed. The custom, of course, as Phavorinus reminds us, was to prevent babbling and to force attorneys to stick to the point.

A famous water-clock was the clepsydra of Ctesibius of Alexandria, which, within limits, was remarkably accurate; and there are records of a magnificent clepsydra constructed for Haroun-al-Raschid (Haroun the Terrible). And perhaps the forerunner of the hydraulic organ was the clepsydra made by Plato, in which flutes played at every hour during the night.

But the clepsydra had one great and ungovernable fault: the inequality of the flow of water. The laws of gravity demand that the flow of water must be greater when a vessel is full than when it is nearly empty; and temperature, too, reacts unfavourably upon

* Pliny, Ep. 6.2.7. Quintilian speaks of *aquam perdere* – wasted time. (Quint. 11.3.52.)

the water flow, which is greater when it is hot than when it is cold.

And yet clepsydrae did attain a remarkable degree of accuracy. With all their faults, these machines were used for centuries. With them the Egyptians are said to have calculated the course of the sun; Tycho Brahe computed the motion of the stars and made the calculations which proved his discovery of a "new star" in Cassiopeia;* and Dudley made his maritime observations. They have played a part, and a not unworthy part, in the history of the human race, no less than in the history of Time.

iii. SAND

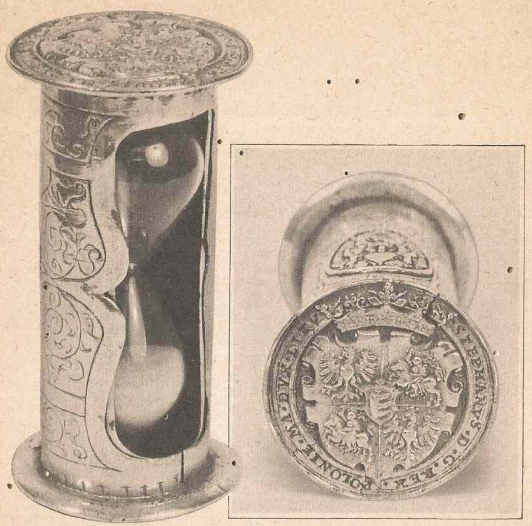
THE HOUR-GLASS is the traditional symbol of Time; it seems to have been part of man's equipment for measuring time since the beginning of things. Yet who invented it, and when, is quite lost.

We know that hour-glasses were in use around the time of the birth of Christ, and the basic principle of sand running from one egg-shaped container to another has remained unchanged for over a thousand years, although sand has not always been the material used. Powdered egg-shells were used in some glasses, and sometimes even mercury.

Latterly, from the sixteenth century to today, hour-glasses were not intended to record continuous time, but to show the beginning and end of a definite period; in churches, for instance, to mark the length a sermon must take, and on shipboard to regulate the crew's watches on deck.

Even today, cooks use them to time the boiling of eggs and, in sharp contrast, the august British House of Commons possesses a venerable two-minute hour-glass which marks the time the division bells ring to call members to vote. Surely, as a means of measuring time, the hour-glass will survive until the end of time.

* Tycho Brahe, *De Nova Stella* (Copenhagen, 1573). This work marked a great advance in astronomy, for it proved that the universe *could* "grow" new stars. Previously it had been considered fixed for eternity.



Hour-glass made for Stephen Bathory, King of Poland (1576-86). It has a handsome gold case. (Reproduced by courtesy of the Trustees of the British Museum.)

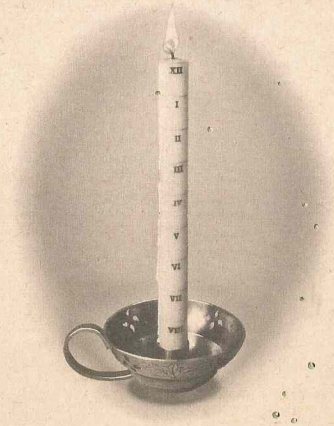
— AND FIRE

THE FACT that a flame burns easily and consistently has inspired men in lands as far apart as Saxon Britain and ancient China to turn this knowledge to the service of time measurement.

The Chinese were familiar with sundials and other methods of time-recording long before they had any contact with the West, and one of their simplest and most useful machines was the fire clock. It consisted merely of a slow-burning taper set beneath

spaced and weighted strings. As the flame burnt through the strings the weights fell into a brass tray beneath, sounding as well as showing the hour.

The Abbés Huc and Gabet, who travelled so perilously through the Far East, found fire clocks still in common use as late as the middle of the last century. Their "Record of a Voyage in Tartary, Tibet, and China" says, "The people often used fire clocks, made with that same combustible material which is widely used in China for sweet-smelling sticks, which burn continually in front of altars of the ancestral cult or idols. This mixture, with a clay base, is composed of sawdust of several species of aromatic trees of Tibet, to which is added musk and gold dust. These sticks, which smoulder slowly without ever going out, are sometimes



One of the simplest clocks ever made, the candle-clock, invented, it is said, by King Alfred the Great. (Crown copyright. Reproduced by courtesy of the Science Museum.)

marked to serve as timepieces; they can burn for several days and they mark the hours fairly accurately. These fire clocks were made in various shapes and could even be used as alarm clocks. At the place marking the hour required, two little weights were hung, tied by a thread. When this was cut by burning, the weights fell into a copper basin and their noise woke the sleeper."

From Saxon Britain came the candle-clock, invented, it is said, by King Alfred the Great. It was perhaps the simplest of all time-measuring instruments, consisting merely of a candle scored with equidistant marks. As the candle burnt down, so the passing of time could be checked and measured.

But many things affected fire clocks and candle clocks; their accuracy was always in doubt. They gave merely a rude approximation of the time; but like all time-measuring instruments, they served a purpose and within their limits, which were known, they served it well.

Middle Watch

THE SCIENCE OF MECHANICS

Middle Watch

THE SCIENCE OF MECHANICS

TO US TODAY, Time means a clock or a watch; a mechanism actuated by wheels, springs and weights to move a pointer on a dial. Moving shadows, falling water, sliding sand, were efficient in their limited sphere, but they were all natural objects or elements, requiring only the principle of their use to be discovered, often needing little or no construction. Between them and the highly accurate timepiece we take so much for granted today, there lies one basic difference – the science of mechanics. When man first turned to his aid a train of wheels, a spring, or weight, and a governor to regulate speed, then were the first seeds of modern horological science sown.

And who that man was, no one knows.

It is odd, when we consider how valuable an invention this was, that all our historians and all our research cannot tell us the name of the inventor.

All the ancient philosophers and scientists who had any claim to a knowledge of mechanics seem to have been credited in turn with the invention of a clock. Archimedes and Posidonius, Boethius, Pacificus, Gerbert, Wallingford, Dondi, all have been acclaimed as the first clockmaker.

The records we have of the sphere of Archimedes, claimed by Claudian to be a clock, seem to indicate that, although it had maintaining power, it was without a regulator. Thus it would not be a clock according to our definition; it would only "measure" time in the same way as a planetarium, which shows the relative velocity of the planets, when turned with a handle.

The sphere of Posidonius, according to Cicero's account of it,*

* Cicero *De Natura Deorum.*

was of the same type. Recent research shows that the "clock" of Boethius was a clepsydra, and also indicates that the same was true of the "clock" of Pacificus. Since claims were advanced for Wallingford and Dondi, it has been proved that clocks were in existence at least a century before their birth.

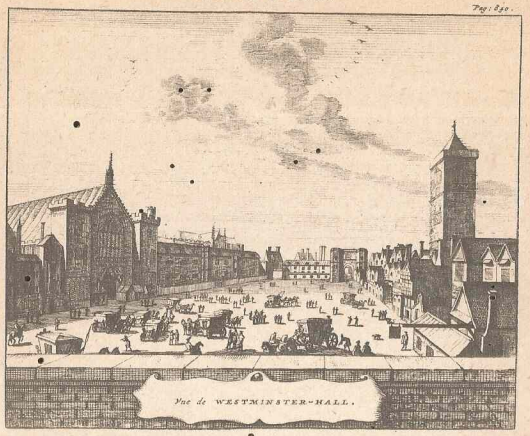
Gerbert's claim at one time seemed sound.

He was a Benedictine monk, who was elected and crowned as Pope Silvester II. In 996 he made a clock for the monastery at Magdeburg, which seemed, from the scraps of records that we had, to have derived its motive power from weights. If this were so, it could claim the title of a clock; but more recent evidence seems to point to the fact that it was nothing more than a sundial.

It must be borne in mind that the word "clock" is derived from the Latin word "clocca," a bell, and it may well be that a clepsydra or sundial determined the times at which a bell should be tolled manually.

Who, then, did invent the clock? Beckman, in an ingenious summary, ascribed its invention to the 11th century, but does not attempt to name the inventor. He also advances the theory that clocks were not of European origin, but were derived from Saracens.

He bases his opinion on a description by Trithenius of a gift to the Emperor of Germany. "In the same year the Saladin of Egypt sent by his ambassadors, as a gift to Frederic II, a valuable machine of wonderful construction, worth more than 5,000 ducats. For it appeared to resemble internally a celestial globe, in which figures of the sun, moon, and other planets, formed with the greatest skill, moved, being impelled by weights and wheels, so that performing their course in certain and fixed intervals, they pointed out the hour, night and day, with infallible certainty; also the twelve signs of the Zodiac with appropriate characters, moved with the firmament, contained within themselves the course of the planet."



One of the earliest mechanical clocks in Europe of which we have records was built at Westminster in 1288, and known as the Great Tom of Westminster. (Reproduced by courtesy of H. Alan Lloyd, M.B.E., F.S.A., F.B.H.I.)

But whenever and however clocks came to Europe, the art of constructing them soon spread, for in about 1288 we find a clock being built at Westminster, London.

This clock we owe to the peccadilloes of the then Chief Justice, Ralph de Hengham. He was tried and convicted for making an alteration in the records whereby a poor dependent was made to pay 13s. 4d. instead of 6s. 8d. De Hengham's motive is not recorded; it seems an odd crime – we are not even told if he pocketed the extra 6s. 8d. – but the upshot was that he was fined 800 marks, and with that money the clock was built.

The tower that housed it was still standing in 1715, but the clock was changed in Elizabethan times. The new clock, however, bore

the Virgilian motto of the old–"Discite Justitiam Monite"–"Learn wisdom from the course of justice." The motto survived until late in the last century, when the dial that bore this reminder of the De Hengham's infamy was removed with the houses which were pulled down in Bridge Street, Westminster.

During the 13th Century, if we can judge from the writings and records of the period, clocks became more and more numerous. In 1292 a clock that cost £30 (a large sum then) was placed in Canterbury Cathedral, and Dante, who died in 1321, refers to a clock that struck the hours:

Indi, come orologio che ne chiami
nell' ora che la sposa di Dio surge
*a mattinar lo sposo, perchè l'ami.**

In 1364 Dondi constructed a clock at Padua for the Prince of Cararra, and won for himself and his descendants in perpetuity the title of *Horologius*. In 1368 Edward I granted protection to John and William Uneman and John Lietuyt, of Delft, three Dutch horologers; and we find Chaucer speaking of a cock crowing with the reliability of a clock:

Ful sikerer† was his crowing in the loge
As is a clok, or any abbey orloge.

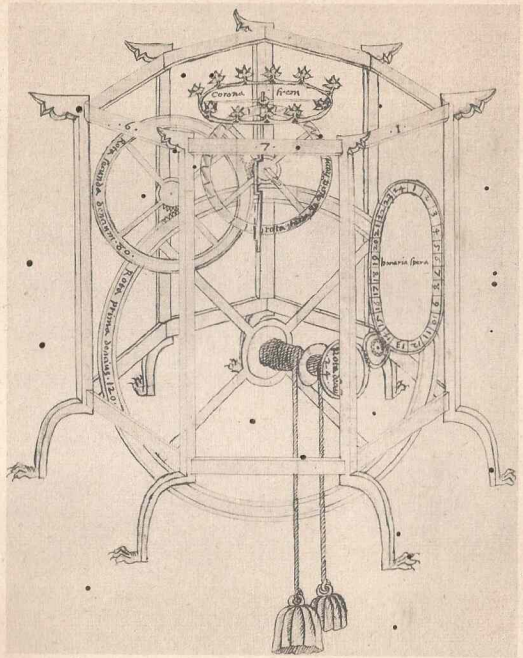
Clocks were fast becoming one of the familiarities of life.

From a weight-driven clock to what we today would call a watch was not an easy step, and it was not until some time in the 15th Century that the first small clock, of which the pocket watch was merely an adaptation, made its appearance.

Its existence depended on the discovery and application of a coiled spring for motive power, for until now the only driving method had been the weight principle.

* Dante *Il Paradiso* Canto X. TRANS: Cary
As clock, that calleth up the spouse of God
To win her bridegroom's love at mat'n's hour . . .

† *Sikerer* – surer.



Dondi's clock, constructed in 1364 by Dondi, at Padua, for the Prince of Cararra. (Reproduced by courtesy of the Bodleian Library, Oxford.)

But, like so many of the important steps in time-telling, no one seems to know who took it.

For a long time, research and tradition credited a young Nuremberg watchmaker called Peter Hele. Doppelmayr says (1730)

"Peter Hele, a clockmaker, was everywhere esteemed a great artist on account of the pocket-clocks which, soon after the year 1500, he first made in Nuremberg, with small wheels of steel. This invention, which with great justice may be ascribed to him being something new, was praised by almost everyone, even by the mathematicians of the time, with great admiration."

But it seems that "almost everyone" was wrong. Recent research by Professor Enrico Morpurgo of the University of Amsterdam, without detracting from the merits of Peter Hele, awards the inventor's palm to the Italians. He holds that the coiled spring principle was known and used in Italy as early as 1400, when it was applied by armourers to the making of roasting spits. In November 1462–almost half a century before Hele won his kudos –Bartolomeo Manfredi was declaring in a letter that he could make a "small watch" for the Marchese di Mantua which will be better than those of the Duke of Modena.

Again, in December 1478, the Marchesa di Mantua was telling her husband, in a letter, that her mother had given her a most beautiful little watch, which she didn't want to send for fear it would be broken.

Even more explicit is a third letter from Camino di Pontevico, the architect, to the Marchese Gonzague di Mantua in 1482 telling him that he has made a watch on the pattern used by "all the other master horologists." From the precise details given, there is no question that this is a genuine watch, constructed some thirty years before Hele.

Most of this Italian 15th Century watchmaking activity seems to have been centred on Mantua, but very soon, by the beginning of the 16th Century, the art of horology was even spreading all over Europe, with Germany, and especially Nuremberg, playing the chief role, although France was second, and there is mention of watches made in Blois, to be set in dagger hilts.

Peter Hele, the horologist of Nuremberg – "everywhere esteemed a great artist." Hele is typical of the conscientious and dedicated craftsmen who added so materially to the science of horology.

Jewellers and engravers were taking a hand, too, and many of the clocks and watches of the 14th and 15th centuries were often richly designed and ornamented.

A clock, now at Windsor, which originally belonged to Henry VIII and was a present from him to the unhappy Anne Boleyn, is a typical example. It found its way into the possession of Lady Elizabeth Germains and was given by her to Horace Walpole, who described it as a clock of silver gilt, richly chased, marvellously engraved, ornamented with fleur-de-lis, tiny heads and crowns. On top sits a lion holding the arms of England; the weights bear the initials H & A (Henry and Anne) held in true lovers' knots; a legend on the top reads "Dieu et mon droit" and at the bottom "The most happy."

Another famous clock of this period is the *memento mori* clock made for Mary, Queen of Scots.

It is in the form of a skull, and was probably intended to be placed on a *prie-dieu*. In the same way it was not unusual for *religious* to add to their beads a miniature skull, as a *memento mori* – a reminder of death and the transience of human life.

Queen Mary's clock bears on its forehead the figure of Death, between a palace and a cottage; around it is a quotation from Horace. The back bears the figure of Time, and between Biblical scenes on the side is marvellously chased lattice work to let out the sound of the bell striking the hours.

But in this welter of ornamentation and richness clockmakers had not forgotten the integral purpose of their clocks; they were always working away in search of greater and greater accuracy. The invention of the coiled spring had superseded the old weight-driving principle and had paved the way for pocket watches; the next step was the pendulum.

Here rises perhaps one of the greatest mathematicians of all time, Galileo. Although he was not primarily a watchmaker, he gave the craft of horology a terrific impetus; and, indeed, in almost every branch of the mathematical arts and sciences, Galileo's name stands among the most eminent.

Galileo, born in Pisa in 1564, gave the craft of horology great impetus. (*Crown copyright. Reproduced by courtesy of the Science Museum.*)

He was born in Pisa in 1564, the son of Vincenzio Galileo, a Florentine nobleman.

He has already gone down in legend; every schoolboy knows the story of his famous demonstration from the Tower of Pisa, that bodies of different weights fall with the same velocity. But were it not for the accident of Fate, Galileo would have been a doctor, according to his father's wishes.

He was trained for medicine; and his father, thinking that to study mathematics would lead him to forsake medicine, held his son carefully aloof from figures.

But Galileo was born a mathematician. His first mathematical observation – the one which was to affect so profoundly the course of European horology – was made when he was only seventeen.

He was in Pisa Cathedral, and, probably when he should have been attending to the service, was idly watching a lamp swinging. Suddenly he noticed that, whatever the range of their oscillations, the lamps swung in equal times; and in that moment the idea of the pendulum was born.

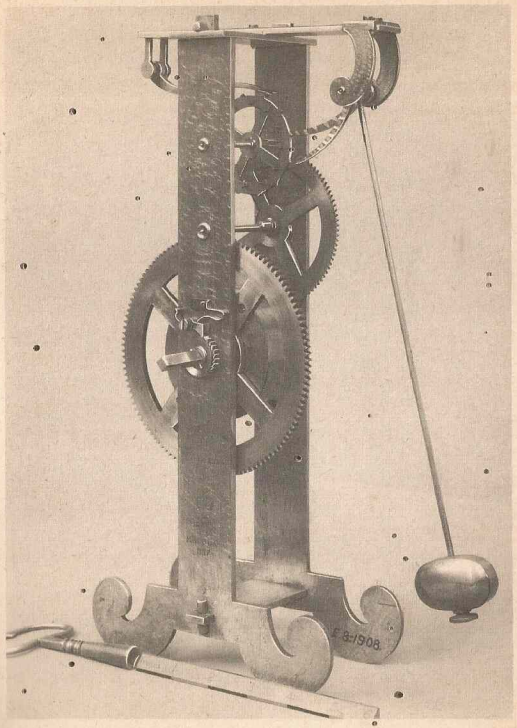
But, true to his medical training, he applied this principle, not to mechanics, but to the timing of the human pulse; it was not until almost the end of his long life that he realized its value in connection with clocks and watches.

Galileo died on January 8th, 1642, and the actual construction of the first pendulum clock is attributed to his son; but it was Christiaan Huygens, the famous Dutch mathematician who, some fifteen years after Galileo's death, fully explored the theory of pendulums,* and he constructed a pendulum clock, on Galileo's principle, well before 1658.

But in the press of famous names, many authorities held that the honours of first applying Galileo's principle goes to an English workman, Richard Harris. If the evidence of the dates is true, he invented a pendulum clock that was set in the turret of St. Paul's, Covent Garden, in the year of Galileo's death, in 1642.

The amazing impetus given to the science of horology by the perfection of the pendulum led to so much greater accuracy that, for the first time, minute and second hands were added to clocks.

* Huygens *Horologium Oscillatorium.* 1673.



Galileo's escapement. The idea of the pendulum came to Galileo in Pisa Cathedral, but not till near the end of his life did he apply the principle to clocks and watches. (Crown copyright. Reproduced by courtesy of the Science Museum. Model showing Galileo's application of the pendulum.)

And this period and this advance saw the emergence of one of the greatest watchmakers of all time—Thomas Tompion, "the father of English watchmaking."

Tompion, whose father was a blacksmith, was born in Northhill in Bedfordshire, in about 1638. It is thought that he, also, first worked as a blacksmith, although this is not certain; the first definite fact we have about him is that he was apprenticed to a clockmaker in London in 1664.

That he was a brilliant clockmaker there can be no doubt. When he began working, the rudiments of clocks, as we know them now, had, as we have seen, already been discovered. The old weight-driven clocks, the earliest form, were still in existence, but they had largely been superseded by pendulum clocks derived from Galileo's discovery. Watches were common, powered by Peter Hele's spring.

Tompion's task was to improve on these bases; and it is to him that we owe many notable advances. He collaborated in the invention of the first cylinder escapement, with the horizontal wheel, which made possible for the first time the construction of *flat* watches.

Together with Robert Hooke, Tompion made one of the first watches with a balance spring; he constructed clocks that ran a year without winding, and were of marvellous accuracy, barometers for the Royal Palaces, and some of the most accurate and intricate watches of that generation. There was little in his sphere that defeated him. He was Master of the Clockmakers Company for nine years; on his death, on November 20th, 1713, he was buried in Westminster Abbey.

But in 1687, some twenty-six years before Tompion died, an incident occurred that marked yet another milestone in the story of time. In that year a man called Nicholas Facio came to London. He was a Genevan, and with him he brought an idea that he had

Thomas Tompion, born in about 1638 ("the father of English watchmaking"). (From the original portrait in the possession of the British Horological Institute, London.)

tried and failed to sell in Paris. It was an idea that revolutionized the construction of watches: the idea of using jewelled pivot bearings.

He commenced working in London, and in 1704 he and two companions, Pierre and Jacob Debaufre, petitioned for the patent they had obtained to be extended. But in the hearing before the committee of the House of Commons, the Clockmakers Com-

pany opposed the application on the grounds, startling to Facio and the Debaufres, that the invention was not a new one. As evidence, they produced a watch made some years before by Ignatius Huggeford, a member of their own company.

On inspecting the watch, the Commons' Committee came to the conclusion that the Clockmakers had made their case, and refused poor Facio's application.

Huggeford's watch has since gained a certain amount of historical reputation; for inspection proves it to be a fake!

Certainly, it had a ruby mounted on the balance cock; but it is doubtful if Huggeford intended it to be for anything more than ornament. Facio's sole purpose in mounting jewels was to provide a new type of bearing for the pivots to work in; Huggeford's jewel could have had *nothing to do with the working of the watch at all.*

History has not yet apportioned the blame for this unfortunate incident; but it occurred at a time when fear of foreign trade was at its height, and may well have been done at the instance of some anonymous watchmaker whose fear of encroachment on his business was greater than his honesty.

The whole affair, however, serves to indicate what importance the art and science of horology had assumed, and the years following Tompion's death marked one of the high spots of European watchmaking; there were great men, great craftsmen, in abundance, to follow in the footsteps of "the father of English watchmaking." Men like George Graham, F.R.S.; Tompion's pupil and son-in-law, Pierre Le Roy; Abraham-Louis Breguet of Paris; the English John Ellicott, and a host of others, were devoting their lives to the cause of horology and striving all the time to make their clocks and watches more and more accurate.

That they were becoming more accurate is shown by the increasing use of them in the science of navigation. As long ago

as 1598 Philip the Third of Spain had offered a reward of 100,000 crowns to any person who could find a means of ascertaining the longitude of a ship at sea. The attempts this offer called forth were only partly successful; the state of horological knowledge meant that they could hardly be more. But in 1714, when a similar offer, of upwards of £10,000, was made by the British Government, great strides had been made. And in this connection one man towers head and shoulders above his contemporaries.

John Harrison was born in 1693 at Foulby in Yorkshire, the son of a carpenter. This remarkable man not only trained himself in clock and watchmaking but taught himself the science and mathematics of horology as well. He devoted the whole of his life to his

Harrison's fourth chronometer won for its designer the British Government's prize in 1764. (The original as exhibited at the National Maritime Museum, Greenwich.)

work, and succeeded in producing clocks and watches far more accurate than those of most of his contemporaries.

In 1725 the Government's offer was still standing, and Harrison set out to "discover the longitude," and win the prize.

The important thing was a watch that would really keep accurate time. The moment of midday at any spot could always be found if the sun were visible; and if the difference in time between local midday and midday at Greenwich were known, the longitude could be calculated exactly.

The majority of people swore that the construction of a watch so accurate was impossible, but Harrison persevered. In 1736 he tried out his first chronometer on an unofficial trip to Lisbon; in 1761, with his fourth watch, he applied for a trial.

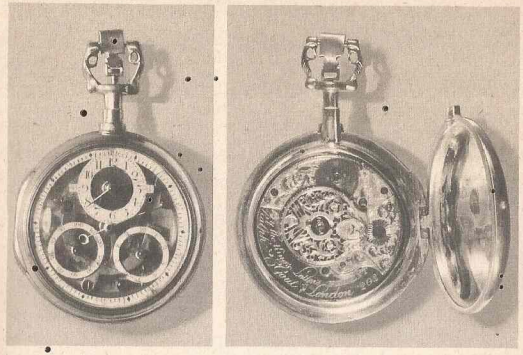
The limits that the government had set were that the watch must determine the longitude within one degree after six weeks' voyage; the award was increased to £15,000 if the error was less than 40 minutes of longitude and £20,000 if it was less than 30 minutes. An error of less than 30 minutes means that the watch had to vary by *less than two minutes in six weeks.*

Harrison's watch erred by five seconds!

In spite of this triumph, he did not receive the award until 1765, when a second voyage, to Barbados, was made and it was found that over three months the watch had varied by less than a minute. And even then, jealousy on the part of some members of the Board of Longitude prevented him getting all the prize money until the personal intervention of George III.

This chronometer made by John Harrison, the son of a Yorkshire carpenter, marked the highest spot yet reached by the science of horology. Gould* calls it the most wonderful chronometer that ever was or ever will be made; and John Harrison's name goes down in history as one of the greatest watchmakers of all time.

* Gould. *The Marine Chronometer.*



One of the early forms of selfwinding watch was that based on the principle of the pedometer, an instrument that measured distance by a weighted lever which jerked as the wearer walked. The illustration shows a watch made on this principle which does, in fact, include a pedometer dial. (*Reproduced by courtesy of the Worshipful Company of Clockmakers.*)

It was also in the early days of the eighteenth century that one of the first references to winding without opening the case of a watch can be found, in the history of the Clockmakers' Company.

In 1712, John Hutchinson applied for a patent for a watch that had a contrivance to wind up this or any other movement without an aperture in the case through which anything can pass to foul the movement.

The application was opposed by the Clockmakers' Company, and by Charles Goode, who produced a movement made fourteen years before. Hutchinson realized and admitted that Goode's movement was similar to his and withdrew his application.

In the years that followed, many other methods of keyless winding were worked out. Caron, in 1752, Litherland, in 1792,

the two Masseys during the latter years of the nineteenth century, all took out patents for keyless winding.

Perhaps the most important innovation was the invention, in 1843, by Adrien Phillipe, a founder of the present famous firm of Pathek Phillipe, of the shifting sleeve keyless mechanism. His construction was later altered by Lecoultre and Audemars, but his original work remains the basis of the winding button that nowadays we take for granted.

The era of Hutchinson's patent application also saw the birth of one of the greatest of English watchmakers, Thomas Mudge. He was born, the son of a clergyman, in 1715, and in about 1757 he invented the lever escapement "which superseded all others."* It is this escapement which has made the modern wrist-watch possible.

But although this great craftsman was an Englishman, England was not long to be the centre of the watchmaking world; Switzerland was coming into her own.

The Geneva Guild of Craftsmen, a watchmakers' company, had long been in existence, and in what is now the old quarter of Geneva, the *Quartier de L'Île*, some of the most famous geniuses of horological science lived and worked.

Their influence on the cause of watchmaking was tremendous; and it was here that the idea of a selfwinding watch was first conceived.

It was the next logical step, and it was in the eighteenth century that the *montre à secousses*, or jerk-winding watch, made its appearance. In England, this type of pocket watch was also called the "pedometer" watch, a name that gives a clue to its mechanism; for it was based on the principle of the pedometer, the instrument for measuring walking steps, deriving its motive power from a weighted lever that jerks as a man walks.

* Chamberlain. *It's About Time.*

Abraham-Louis Perrelet, of Le Locle, Switzerland, born when the great John Harrison was thirty-six, has valid claims to be the inventor of the selfwinding watch.

Two men have frequently been cited as the inventors of the selfwinding watch — Breguet of Paris and Louis Recordon of London; and Herbert Sarton of Liège also constructed one between 1770 and 1775. Various mentions, which have unfortunately been left vague, attribute the first attempts at so-called "perpetual" watches to a German inventor of the 17th Century. But, as the historian Pierre Dubois says, "There is no parallel point between

these first attempts and the 'mass-production' of A.-L. Breguet." And in recent years, evidence has pointed to Abraham-Louis Perrelet of Le Locle, in Switzerland, as the most probable begetter.

Perrelet was born when the great John Harrison was thirty-six – his life overlapped that of Harrison's. This is a circumstance we can see all through the story of Time. As one great man is born, does his work, and dies, another is developing to wear his mantle.

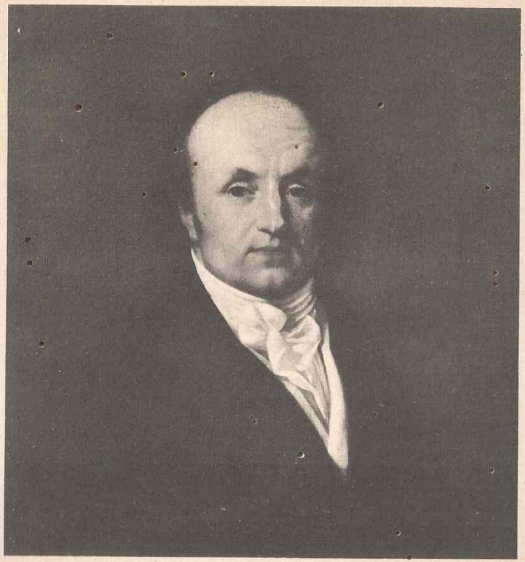
Perrelet devoted his life to his craft. He lived to the age of ninety-seven, and all his life he dreamed and worked in the cause of his chosen trade.

He was perhaps the master of Swiss watchmakers of his time.

The evidence that he first made a selfwinding watch is fairly conclusive. The *Biographie Neuchâteloise* (1863) says of him: "It was he who invented the perpetual or pedometer type of self-winding watch, the mechanism of which winds itself up by the impulse given while it is being worn. The first watches of this kind made by Perrelet were bought by Breguet and by a certain Recordon who lived in London. These pocket watches were fairly practical, except for the size. He had also conceived a device whereby they could be wound with a key when not in use."

This statement was based on the reminiscence of Henri-Ernest Sandoz, of Le Locle, who knew Perrelet personally, and was related to him. And there is evidence that Breguet and Perrelet were acquainted. Breguet, writing to a friend, says of the older man, "He had a wife so wicked that she became mad"; which gives us a fascinating subject for speculation on the unhappiness of Perrelet's home life.

None of Perrelet's watches survives to-day; but in 1780 Breguet was making selfwinding watches on Perrelet's principle, and Recordon was applying for Letters Patent to manufacture them in England, so it is reasonable to assume that Perrelet's invention was perfected some time in the 'seventies or 'eighties.



Abraham-Louis Breguet, one of the greatest of horologists. Born in Switzerland in 1747, he took a great part in developing the selfwinding watch. After a long and distinguished career, he died in 1823, at the age of seventy-six.

Little is known of Recordon's life, although Letters Patent (No. 1249) were granted to him in 1780 for his automatic winding device; it would seem that at first he merely acted as an agent to Breguet. But Breguet himself has become one of the most famous names in watchmaking history. Sir David Salomons' book, "Breguet," published 1923, shows many magnificent watches

made by this master, including no fewer than eleven selfwinding watches.

Breguet had succeeded in adapting Perrelet's principle of self-winding to many different types of watch. The weight differed in shape according to the intricacy of the movement, and in some cases the click-work is very complicated. But his masterpiece is undoubtedly the "Marie Antoinette" watch.

It was commissioned for Queen Marie Antoinette by an officer of the French Royal Guard in 1783. Breguet worked on it intermittently from 1789 to 1802, the French Revolution interfering, and when it was finished, no known intricacy of the horologist's art had been neglected.

It was selfwinding, and a minute repeater; it bore a calendar, with a time equation, and even a thermometer. The luxurious outer case was never completely finished, but even so, it bears, to our modern eyes, all the exquisite delicacy of the taste of the period.

But Perrelet's jerk-winding principle had been only partly successful. The chief drawback was that the continual jerking of the weight damaged the movement in a very short time. In nearly all the watches of that period that have survived, the movement has seriously deteriorated. The only exceptions are some watches made by Breguet, for special customers, and into which he put a great amount of care.

In about 1877, a somewhat different form of pedometer watch made its appearance. It is described in a patent taken out by Edward Fletcher, and further new patents were taken out by von Loehr (1879) and Brun (1883), by van der Heydt (1884) and Villeumier Brothers (1892).

It was obvious then, that watchmakers were striving to solve this problem. But none of the watches of this time threw any light on it. And neither did these years help in the other great aim—the waterproof watch.

Ever since the invention of the coiled spring, watches were becoming more and more accurate, and as they became so, watchmakers began to realize that only in a perfectly protected watch could perfect accuracy be obtained. "Waterproof" is perhaps a misnomer; the watches were intended to be not only proof against water but, more important, against dirt and damp and perspiration. The first attempts to make watches more dustproof were made in the 17th century, when rings, called dustproof bands, were fitted. In about 1750, these bands covered the whole of the movement, and were known as "caps." But somehow, these dustproof devices were never a complete success. Watchmakers went on trying to perfect them, but no new development occurred until later in the 19th century, when a Genevan watch-case maker, François Borgel, took out a patent for a case made in a single piece, with a threaded edge screwing directly on to a threaded band which held to the movement. This trick certainly provided better

Breguet's intricate masterpiece, the "Marie Antoinette" watch, commissioned for the ill-fated Queen by an officer of the French Royal Guard in 1783. (Reduced in size.)

protection, but the crux of the problem, the winding stem, remained unsolved; the case was not waterproof nor even completely dustproof.

These years of the nineteenth century were not remarkable for great advances in matters connected with the case. Watchmakers concentrated on greater and greater accuracy, and were pleased if they managed to bring their watches a few seconds nearer perfection.

They worked on tiny adjustments where a fraction of a millimetre was an achievement. The escapement invented by Robert Houdin, the conjuror, was great news. Sir Robert Airey's researches were hailed with joy.

And so the age of Wilde and Whistler approached. *Fin-de-siècle*, the turn of the nineteenth century. And in the watch trade, the coming of the wrist-watch.

Morning Watch

TODAY AND TOMORROW

Morning Watch

TODAY AND TOMORROW

IN THE EARLY DAYS of the twentieth century, watchmaking had reached, it seemed, the highest peak of perfection. And the watches of this date were, certainly, remarkably fine. A gold watch was a mark of the man, of respectability. A tall hat, a stool in the City, a gold half-hunter, were the signs by which a man could show that he had arrived.

The wrist-watch was just making its appearance, amid a chorus of derisive laughs; it must, argued watchmakers, prove to be a failure. The mechanism needed, they said, must be so small that it could never withstand the violent gestures of hand and arm. Anyway, however well constructed the movement was, it could never withstand the attacks of dust and damp. Anyway, so small a movement could not possibly be accurate. Anyway, the public didn't like it.

It was certainly true that the public didn't at first take kindly to the wrist-watch. ". . . Who remembers when cuffs on a man's trousers brought down the jibe 'It's raining in London'? Only Cholly-off-the-pickle-boat wore white ducks and, to jump ahead a bit, several prominent citizens of today are on record as having once said they would as soon wear a skirt as a wrist-watch."*

Only a few enterprising firms were prepared to manufacture and sell wrist-watches. And they were soon proved right. Public opposition was gradually overcome, and by 1905 the new vogue was taking hold.

By 1914 it had been proved that a wrist-watch could keep time just as accurately as a pocket-watch; it was to be proved that it could almost equal the accuracy of a marine chronometer.

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* Robert Benchley. *My Ten Years in a Quandary* (Collected Essays).

But before this standard could be reached, the watchmakers had to face one perennial problem.

Their critics had been right in at least one respect. The movement of a wrist-watch *did* suffer a great deal of damage from outside influences; far more than in the less delicate pocket-watches, certainly far more than the sturdy clock mechanism.

And it was partly because of this that the old idea of a waterproof watch cropped up.

A completely waterproof case, watchmakers realized, would, *ipso facto*, provide the protection that was vital if their wrist-watches were ever to reach the standard they had set themselves.

But they were thinking far into the future, thinking in terms of hundreds of watches made for sale. It was perfectly possible to produce one highly accurate wrist-watch, and prove that the necessary delicacy of action could be obtained.

In 1914, a wrist-watch, made by the Rolex Watch Company, won, for the first time in history, a Kew "A" Certificate. Kew Observatory, now at Teddington and officially known as the National Physical Laboratory, is the ultimate testing ground for clocks and watches from all over the world.

The Class "A" Certificate is their highest award and is extremely difficult to win.

It is normally a test for large chronometers. Each movement undergoes five "position" tests and three "temperature" tests. The positions are: horizontal: dial up and dial down; vertical: crown (winding button) to the left, crown to the right and crown down. And the three temperature tests are ambient (roughly 67°F.); cold, 40°F., in a refrigerator; and hot, 92°F., in an oven.

The tests last for 44 days and nights, yet the Rolex wrist-watch submitted passed with honours.

This was a remarkable result, and it showed plainly that a wrist-watch could be an accurate time-measuring instrument.

Mr. H. Wilsdorf, Founder and Chairman of the Rolex Watch Company, photographed on the occasion of his seventy-fifth birthday. Mr. Wilsdorf early appreciated the possibilities of the wrist-watch, and, in 1905, became the first man in the world to market a wrist-watch with a lever escapement.

But it was still difficult to produce such accurate wrist-watches, in quantity, and for sale; and the question of a completely waterproof case was still occupying manufacturers' minds to a very great degree.

The solution was found by a man who was not primarily a technician, but a business man.

H. Wilsdorf, the founder and Chairman of the Rolex Watch Company, was born in 1881, and he entered the Swiss watch industry as an English correspondent and clerk in 1900.

Five years later, in England, he founded the watch-importing firm of Wilsdorf and Davis; and by 1919 this firm had transferred its headquarters to Geneva and had become the Rolex Watch Company.

Long years of experience of watchmakers and their problems and foibles taught Wilsdorf many things about the technical side of the trade; he had realized what a great advance could be made

with a really waterproof case. He determined to try and succeed where so many others had failed.

Step by step the new watch case was worked out. Its manufacture needed craftsmanship of a very high degree, for the machining and hand finishing of the parts demanded incredible accuracy.

But when the new case and winding crown were completed, trials confirmed their success. A number of watches taken at random from the normal serial production were immersed in water for a period of three weeks. On being tested, they showed little or no variation; and subsequent scientific and actual tests showed that these results had not been merely a fluke. The problem of the waterproof watch had, in fact been solved. That watch the world knows today as the Rolex "Oyster".

To many people at that time, it seemed a joke—a "gimmick"—that had nothing to do with time-keeping. But Wilsdorf and his colleagues knew that it was a revolution.

For the point of a waterproof watch is protection not so much against water, but against dust, sand, grit, and all other elements that can damage the movement and clog the vital oil.

Today the waterproof watch is no longer comic. Almost every watch manufacturer offers a selection of "waterproof" watches. The joke has turned into attempts to catch up with Rolex.

The Rolex Oyster has come a long way since the day in 1927, when Mercedes Gleitze made world headlines by swimming the English Channel with an Oyster on her wrist. Since then Rolex Oyster watches have equipped expeditions to the highest mountains, including the successful Everest expedition of 1953, led by Sir John Hunt. They have crossed the sound barrier hundreds of times and penetrated to the depths of the sea, for Rolex have developed Oysters, that can go down wherever men can go. The navies of three great nations use Rolex for special underwater activities.

With a perfect protection for an intricate movement, the way

was now cleared for greater and greater accuracy – and cleared, too, for the attack on another age-old problem, that of the self-winding watch.

The most recent advance had been that made by John Harwood, an Englishman from Bolton, Lancashire, who had perfected his selfwinding wrist-watch soon after the first world war; but Wilsdorf decided to discard the ubiquitous hammer-jerk principle as impracticable, and, with his technicians at the Rolex factory in Bienne, he formulated the rules which are taken as standard for most selfwinding watches to-day. It had to be, he considered, completely automatic, silent, able to revolve both clockwise and anti-clockwise, absolutely smooth in action, and completely dispensing with buffer springs.

And in 1931 world patents were taken out for the "rotor" mechanism.

In this new selfwinding watch, the "Perpetual," the winding mass, the "rotor," is no longer a part moving to and fro against banking springs. It is a prime mover, able to turn clockwise and anti-clockwise and pivoting freely on its staff in the centre of the movement. Semi-circular in shape, its equilibrium is unstable, so that it is able, by the force of gravity, to fall constantly into a new position, often making a complete revolution.

Tests proved that the new mechanism was foolproof; and not only did it wind the watch up, but it was discovered that even greater accuracy could be obtained, as the tension on the mainspring was much more constant than when a watch is wound by hand once every 24 hours.

Today, nearly all Swiss watch-making houses use the Wilsdorf "rotor" principle in their selfwinding watches, and this acceptance by the industry is perhaps the highest accolade it could receive.

Nineteen thirty-one, then, saw the complete justification of the wrist-watch. It had been proved that such a watch could function

with chronometer accuracy, that it could be waterproof, and that it could be selfwinding; and, what is, perhaps, more important, that such watches could be produced in quantity for sale.

But even then, advances were possible, and Rolex have always made it their business to be in the forefront of watchmaking research. Consider, for instance, the present pride of the Rolex production. It is called the Daydate and is the most advanced wrist-watch you can buy.

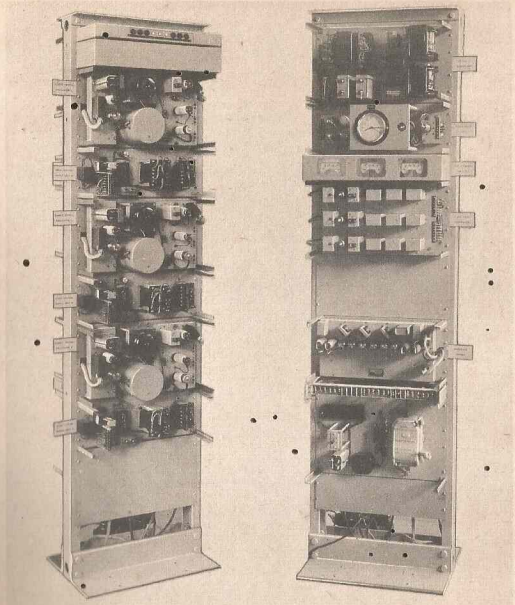
It has a chronometer movement; it is waterproof; it winds itself; it not only shows the date, the figures magnified by a special tiny lens, but it shows the day of the week in full, as well. And when midnight strikes, the date and the day change not slowly, like on other calendar watches, but with automatic precision, and the speed of a camera shutter.

The care and skill exercised by the Swiss watch industry in producing these watches is perhaps best exemplified in the testing rooms and laboratories of one of the premier watch firms.

The Rolex Watch Company submit their watches to incredibly exhaustive tests. With their waterproof "Oyster" watches, for instance, it is not enough merely to plunge the case in water and then examine the inside for damp. This really is no proof, so they have developed a special apparatus which can detect the presence of the tiniest fault in the case itself.

When the watch is put into this machine, a vacuum is created similar to the pressure that would be found 20 to 30 feet under water. Any imperfection in the watch case means that the air inside escapes and floats to the surface in the form of tiny bubbles; and one bubble seals the death warrant of that particular case.

Any new models or prototypes, and often watches from the normal serial production, are also tested in a gas chamber. The case, with a piece of sensitized paper inside, is laid in a chamber and a similar piece of sensitized paper is laid beside it. The chamber is



The Quartz Crystal Clock installed in Greenwich Observatory in 1942, used for the B.B.C. time signals. It is accurate to within one thousandth of a second per day. (Crown copyright. Reproduced by courtesy of the Science Museum and Engineer-in-chief, G.P.O.)

hermetically sealed and gas is pumped in. The outer paper, affected by the gas, changes colour; but if the paper inside the case shows the slightest sign of change, back to the factory goes the case.

In all fields of watchmaking today, science is coming to the aid

of the watchmaker. Cathode rays screen the ticking of a watch visually, so that the slightest falter can be seen at once. That falter may mean a considerable inaccuracy, so back for adjustment goes the watch.

Out of these years of accelerating progress, in which science has joined hands with the manual arts, have arisen watches of such infinite accuracy and superb craftsmanship that their owners are constantly amazed at their incredible performances. Fantastic stories, from all over the world, are received by the manufacturers.

Consider, for instance, the case of Professor Cutolo of Milan University. He had a watch made by Rolex; one of their standard "Oyster Perpetual" (waterproof and selfwinding) models. He was on holiday, and swimming off Capri, when the buckle of his watch-strap gave way and the watch fell off his wrist.

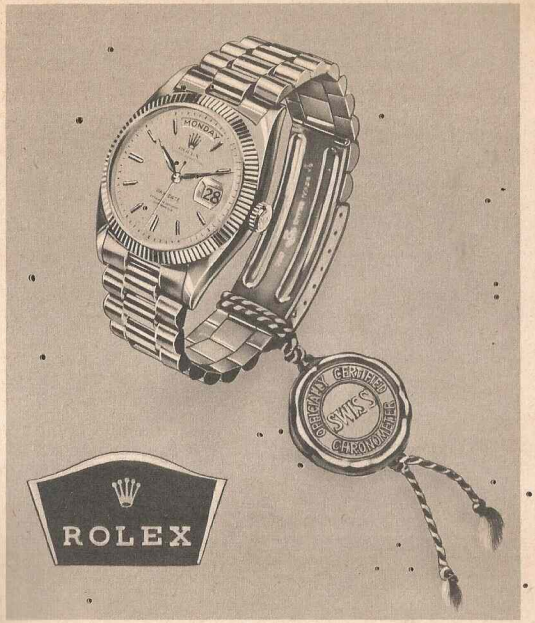
But there were some Italian divers working on the sunken Italian fleet, and with what seems remarkable optimism, Professor Cutolo asked them to look for his watch.

But however remarkable his optimism, it proved to be completely justified; for, three days later, the divers found the watch, and brought it to the surface.

Not only was it still in going order, but it was still going; *the tug of the waves had been sufficient to actuate the selfwinding mechanism.*

Then there was the Rolex "Oyster" that was dropped into Shawnigan Lake in British Columbia, and recovered several months later in perfect condition; and the Rolex "Oyster" that crashed in a wrecked aircraft, lay buried for four years, was recovered, cleaned and wound, and went perfectly.

But brute strength is not the be-all and end-all of a modern watch. Its function, first and last, is to tell the time; and in this, too, watches available to everyone excel, for many of them approach the standards set by clocks in the world's observatories, which are large scientific instruments.



Combining the Oyster case, the first truly waterproof case in the world, and the famous "rotor" selfwinding mechanism, the Rolex Daydate is the pride of the Rolex production. It shows not only the date, magnified by the Cyclops lens, but the day of the week as well, both changing instantaneously and automatically at midnight every night.

The Rolex Watch Company, indeed, make a point of insisting that the cream of their production reaches chronometer standard, and from 1914, when Kew Observatory awarded them a Class "A"

Certificate for a small lady's watch, until today, the margin of error has consistently decreased.

And it is still decreasing. In laboratories and observatories all over the world there are clocks so accurate as to need other special instruments to detect their infinitesimal error, clocks within a millionth part of being as accurate as the stars.

But these, remember, are *special* clocks – electric quartz crystal-controlled clocks. So accurate are these clocks that an irregularity in the rotation of the earth itself has been discovered by means of them!

The clocks and watches available to us, to the ordinary man-in-the-street, cannot compare with this almost unbelievable accuracy. But, for our everyday purpose, the modern watch is, indeed, a masterpiece, and further refinements are being added at breath-taking speed.

The latest achievement is the Rolex "Oyster Perpetual Daydate," a wrist-chronometer of incredible accuracy, which is not only water-proof and selfwinding, but shows the date and the day of the week as well, written in full in small windows on the dial face. Both the date and the day change automatically and instantaneously every midnight. This is a vast improvement on the erratic clepsydra of 1400 B.C.!

Three thousand years is a long time; and it is almost three thousand years since the Berlin sundial was made. Three thousand years of progress has refined time to a split second, and a procession of great men who have devoted their lives to achieving this miracle stretches back through the centuries.

Abu'l Hassan figuring in the sand, and Plato listening to the delicate music of the time-telling flutes. Queer, crabbed, old Sebastian Münster scribbling away in Nuremberg; and young Galileo dreamily watching the swinging lamps of Pisa Cathedral. Thomas Tompion, who lies in Westminster Abbey, is among

them, and so is stout, stolid, Yorkshire-born John Harrison. Here is Thomas Mudge, inventor of the lever escapement, and there, poor Perrelet, tied to a mad wife, slaving away to the end of his long life, and Breguet, dreaming and working while the French Revolution roared about his ears; Robert Houdin making rabbits disappear and inventing the barrel escapement. Great names, many great names; all devoting their lives to that extraordinary dimension we call Time.

And, really, that is just as it should be. For surely not one of us, even the least imaginative, can consider Time without *some* feeling of awe. . . .

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